RESEARCH ARTICLE OPEN ACCESS

Characteristics of Hand Transmitted Vibration through Steering Wheel of Tractor during Ploughing Field

Md Zakaullah Zaka[1], Mohd Saad Saleem[2], Munaim Akhtar[3], Abdul khaliq[4], Saimah Khan[5]
Department of Mechanical Engineering, University Polytechnic, Integral University Lucknow , India

Abstract
The paper presents the transmission of vibrations through the steering wheel of the tractor during the ploughing field. The measurements of vibration were carried out on the tractor randomly chosen. An investigation was conducted to determine the transmission of vibration from the steering wheel of the tractor to the wrists and upper arms of the operator under actual field conditions during ploughing field. The vibrations transmitted through the steering wheel of the tractor to the hand of the operator was measured and the frequency spectra for the chosen working conditions were obtained. The maximum transmissibility of vibration were observed in the first two frequency interval (in Hz) i.e. 1-20 and 20-40. The vibration, which is transmitted from the steering wheel of the tractor to the wrists, arms and shoulders causes discomfort to the operator and results in early fatigue.
Keywords: Hand Transmitted Vibration, LabVIEW, Power spectral density, Tractor

I. Introduction

The vibration, which is transmitted from the handle of the tractor to the hands, arms and shoulders, causes discomfort to the operator and results in early fatigue. An investigation was conducted to determine the transmission of vibration from the handle of the hand tractor to the metacarpal, wrist, elbow and acromion of the operators under actual field conditions during transportation on a tarmacadam road, rota-tilling in a dry land and rota-puddling in a wet land condition. The maximum transmissibility was observed during the rota-tilling operation. The work related body pain (WRBP) was maximum during the rota-tilling operation, followed by transportation and rota-puddling.[3]. The vibration transmitted from the steering wheel of the small tractor with a four wheel drive to the hands of the driver were carried out on the tractor which is randomly chosen. The vibration level has been measured at idling and full load. The vibration level on the steering wheel were measured and analyzed and the frequency spectra for the chosen working condition were obtained.[4]. The term 'hand-arm vibration' is frequently used to refer to vibration from power tools, but it does not clearly indicate whether the hand and arm are the origin of the vibration or the limits of its effects. The expression 'local vibration' suggests that the effects are localized near to the point of contact with a source of vibration. While some effect can, by definition, only occur in the fingers or hand, the vibration is transmitted further into the body and the effects it produces there may be of interest. it is therefore more satisfactory to refer to hand transmitted vibration, meaning vibration entering the body at the hand.[5]. The vibration is transmitted through steering wheel of tractor during ploughing field to the operator wrists, arms and shoulders at different frequency interval. The maximum transmissibility observed in two frequency interval (in Hz) 1-20(target-wrist), 1-20 (target-upper arm), 20-40 (base-steering), 20-40 (base-steering).[11]

II. Methodology

In this study level of vibration transmitted to hand of tractor driver while on ploughing field by using LabVIEW code and Two integrated electronic piezoelectric (IEPE) sensor connected to the NI USB-9233 data acquisition device interfaced were recorded with a laptop. The recorded data auto stored in text/excels files in the laptop. The recorded data analyzed by using MATLAB programme. A LabVIEW code was written to design the instrument for the recording of vibration levels is shown in figure (1). The data acquisition was made possible using tri axial transducer (model no. SEN041F was made by PCB piezoelectronics, NEW YORK,USA; having 10.23 mV/g,10.66mV/g and 10.41Mv/g sensitives in x, y, z direction respectively, the certificate is enclosed as appendix A)that was connected to NI card (Model No. NI9234 made by National instruments)using lead and the card was interfaced with a Acer laptop (specifications P6000 PROCESSOR ,3 GB RAM).The setup was supportive to the sampling rate of 26,400 per second .However the mean values were only recorded .The recorded data was auto stored in text/excel files in the laptop. The items used in the experimental setup are shown in figure (2). Procedure to measure the vibration on tractor steering is very much standardized. Vibration measurement on tractor steering have been performed, vibration are measured along z- axis vertical axis. We are using NI USB-9233 data acquisition device. The USB-9233 consists of two components: an NI 9233 module and aUSB-9162 USB carrier, for vibration measurement, NI USB-9233 connected with personal computer through lead.

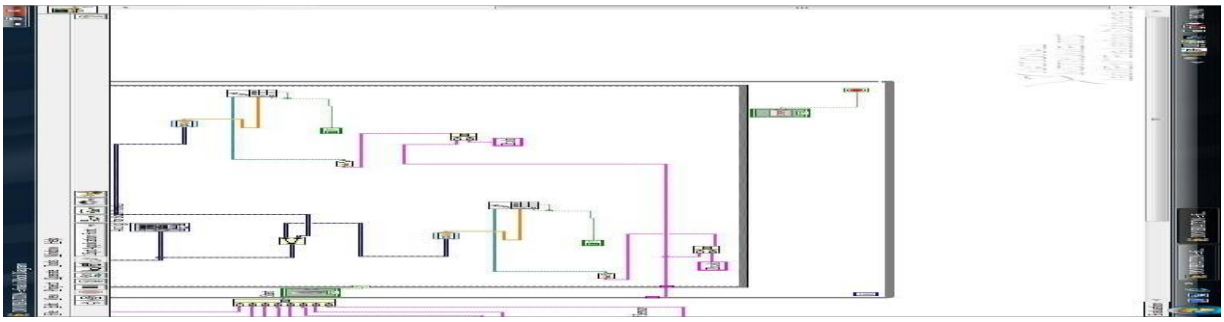

Figure 1. : The block diagram of LabVIEW code used for the recording of vibration levels (in g)

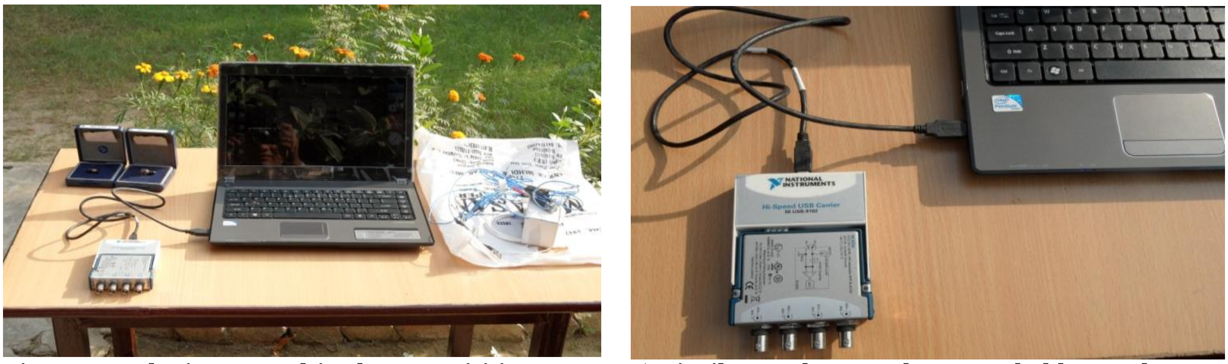

Figure 2 : The items used in data acquisition process (Triaxil transducer, Adaptor to hold transducer, data acquisition card and interfacing with Laptop)

Two integrated electronic piezoelectric (IEPE) sensor connected to BNC connector .One of the sensor are attached to steering (z-base) and second one sensor are attached to driver forearm and upperarm (near shoulder) (z-target) ,so we get The collected data was processed and analyzed with LabVIEW TM and by using MATLAB programme for each test. First and foremost subject of the test was given written information about the experiment, which included the purpose of the study. The tractor that are used in experiment was in working condition, tyres of the tractor for the test were of standard size. Tests are carried out on FARMTRAC 50 model on ploughing field which is shown in figure (3).

Figure 3 : (a) FARMTRAC 50 model on ploughing field , (b)Sensors position on steering and lower arm (wrist), (c) Sensors position on steering and upper arm

Farmtrac 50 from Escorts Ltd. is a 4 stroke, direct injection diesel run tractor with a capacity of 2868 cc. The vehicle comprises a mechanical constant mesh gearbox with 8 forward and 2 reverse gears. Farmtrac 50 is equipped with a recirculation ball type, worm and nut with double drop arms steering and also has an option of a

power steering. The tractor is featured with drum (internal expanding shoe) brakes along with a hand operated parking brake.For measuring vibration, the tractors were moving on a specified field with certain speed. The test is carried out on tractor without any trailer attached with it but load attached to it like ploughing equipment. Subjects were considered to be healthy with no signs of musculo-skeletal system disorders. I am using two sensor for measurement of vibration in z direction, first sensor is SEN041F triaxial shear icp accelerometer ,this recognized as a z-base sensor ,it is attached to tractor steering of Farmtrac -50 model tractor to measure its vibration at steering ,second sensor used for test is 353B18 SN 140184 ,it is recognized as a target sensor ,this sensor attached to subject forearm and upper arm to measure the vibration transmitted to the hand of the subject.
First sensor attached to DAQ via blue cable at terminal A0-1 and second sensor is attached to DAQ via white cable at terminal AI-1. Figure (4) Shows the screen shot of the LabVIEW code for recording vibration levels in Z- direction.

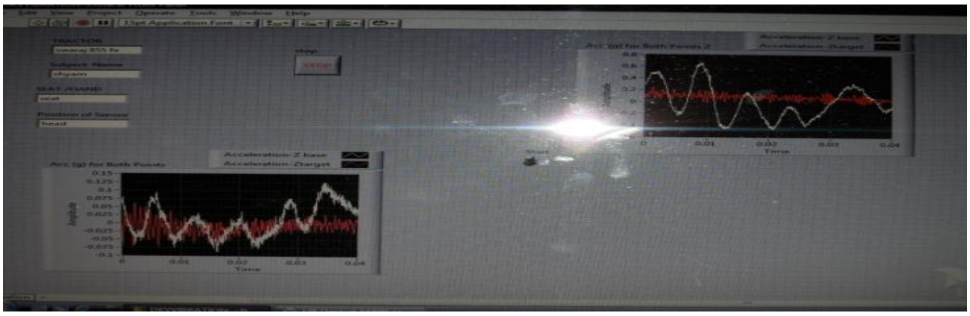

Figure 4: Screen shot of the LabVIEW code for recording vibration levels in Z direction.

III. Results

The tractor that are used in experiment was in working condition. Tests are carried out on FARMTRAC 50 model on ploughing field. The test is carried out on tractor without any trailer attached with it but load attached to it like ploughing equipment. the vibration transmitted to hand through steering of tractor has taken by using LabVIEW code with the help of laptop. The recorded data was auto stored in text/excel files in the laptop. So we get the collected data was processed and analyzed with LabVIEW TM and by using MATLAB programme for each test. The following tables shows the power spectral density at different frequency zone.

TABLE-1: Power spectral density at different frequency zone for z-base on steering.

Serial no.	Sensor position	Frequency zone(Hz)	Power spectral density
1	Base(steering)	1-20	0.1005
2	,,	20-40	0.2066
3	,,	40-60	0.1166
4	,,	60-80	0.0373
5	,,	80-100	0.0060
6	,,	100-120	0.0004
7	,,	120-140	0.0000
8	,,	140-160	0.0000
9	,,	160-180	0.0000
10	,,	180-200	0.0000

Table-2: Power spectral density at different frequency zone for z-target on wrist.

Serial no.	Sensor position	Frequency zone(Hz)	Power spectral density
1	Target(wrist)	1-20	0.0022
2	,,	20-40	0.0000
3	,,	40-60	0.0000
4	,,	60-80	0.0000
5	,,	80-100	0.0000
6	,,	100-120	0.0000
7	,,	120-140	0.0000
8	,,	140-160	0.0000
9	,,	160-180	0.0000
10	,,	180-200	0.0000

Table-3. Power spectral density at different frequency zone for z-base on steering.

Serial no.	Sensor position	Frequency zone(Hz)	Power spectral density
1	Base(steering)	1-20	0.1072
2	,,	20-40	0.1531
3	,,	40-60	0.0470
4	**,,**	60-80	0.0382
5	,,	80-100	0.0043
6	,,	100-120	0.0003
7	,,	120-140	0.0000
8	,,	140-160	0.0000
9	,,	160-180	0.0000
10	,,	180-200	0.0000

Table-4. Power spectral density at different frequency zone for z-target on upper arm

Serial no.	Sensor position	Frequency zone(Hz)	Power spectral density
1	Target(upperarm)	1-20	0.3974
2	**,,**	20-40	0.0011
3	,,	40-60	0.0006
4	,,	60-80	0.0005
5	,,	80-100	0.0004
6	,,	100-120	0.0004
7	,,	120-140	0.0004
8	,,	140-160	0.0004
9	,,	160-180	0.0004
10	,,	180-200	0.0004

The following table-5 shows the maximum power spectral density in accordance with the frequency zone.

Table -5: Maximum power spectral density in accordance with the frequency zone (in Hz)

Serial number	**Sensor Position (in Hz)**	**Frequency zone (in Hz)**	**Power spectral density (maximum)**
1.	Base (on steering)	20 - 40	0.2066
2.	Target(wrist)	1 – 20	0.0022
3.	Base(on steering)	20 - 40	0.1531
4.	Target (upper arm)	1 – 20	0.3974

IV. Discussion

The vibration transmitted to hand through steering wheel of tractor has taken by using LabVIEW code with the help of laptop. The recorded data was auto stored in text/excel files in the laptop. So we get the collected data was processed and analyzed with LabVIEW TM and by using MATLAB programme for each test. The results we get in the form of tables- 1,2,3 and 4.Table-1 shows the vibration level on steering and table-2 shows the vibration level on wrist. likewise, table-3 and table-4 shows the vibration level on steering and upper arm. The vibration level on the steering and target point wrist and upper arm has measured and analyzed and the frequency spectra for the chosen working conditions were obtained. It is also suggested by [11] that the maximum transmissibility was observed in the first two frequency interval (in Hz) i.e. 1-20 and 20-40. The frequency interval was 1-20 (target-wrist), 1-20 (target-upper arm), 20-40 (base- steering),20-40 (base-steering) and frequency zone was 0.0022,0.3974,0.2066,0.1531 respectively. Above result table- 5 shows that the maximum power spectral density in accordance with the frequency zone (in Hz). It seems that the power spectral density is maximum at the target point shoulder i.e. 0.3974 in comparision to the target point wrist i.e.0.0022. The vibration is transmitting at target point shoulder is more than the target point wrist.

V. Conclusion

The major conclusions can be drawn from the present investigations the frequency zone 1-20 and 20-40 are the most harmful for the tractor driver. The vibration, which is transmitted from the handle of the tractor to the wrists, arms and shoulders, causes discomfort to the operator and results in early fatigue. This study helped in understanding the effect of vibration level on tractor operator. The results indicated the value of research work aimed at reducing vibration levels. Ergonomic studies are recommended to determine the vibration response in agricultural production activities.

References:

[1.] Dewangan, K.N., and Tewari, V.K.,2009, 'Characteristics of hand transmitted vibrationof a hand tractor used in three operational modes' , International Journal of Industrial Ergonomics , volume 39, issue 1, pp 239-245.

[2.] Dewangan,K.N. and Tewari,V.K.,2009, 'Vibration energy absorption in the hand arm system of hand tractor operator' , Biosystems Engineering , volume 103, issue 4 , pp 445-454.

[3.] Dewangan, K.N., and Tewari,V.K.,2008, 'Characteristics of vibration transmission in the hand arm system and subjective response during field operation of a hand tractor' , Biosystem Engineering , volume 100, issue 4, pp 535-546.

[4.] Goglia,V., Gospodaric,Z., Kosutic,S.,and Filipovic,D.,2002, 'Hand transmitted vibration from the stearing wheel to drivers of a small four-wheel drive tractor', Applied Ergonomics, volume 34, issue1, pp 45-49.

[5.] Griffin,M.J. 'Handbook of Human Vibration', Reprinted (2003-2004), pp 530-531.

[6.] Goglia, V., and Gospodarić , Z., 2002, 'Driver's exposure to hand-transmitted vibration from the steering wheel of the LPKT 40 tractor, The 30th International Symposium on Agricultural Engineering', Opatija.

[7.] ISO 5349-2-2001, 2001. EN ISO 5349-2, 2001. Mechanical vibration—measurement and Evaluation of Human Exposure to Hand-Transmitted Vibration—Part 2: practical guidance for measurement at the workplace.

[8.] ISO 5349-1, 2001. ISO 5349-1-, 2001. Mechanical vibration—measurement and evaluation of human exposure to hand-transmitted vibration—Part 1: general Requirements, ISO, Geneva.

[9.] Kacian N. ,1997, 'A statistical report on occupational diseases in Croatia. Work and Safety' **2** , p. 271.

[10.] Wasserman, D.E., 1987, 'Human vibration and Biomedical Engineering Consultant, Cincinnalu' , OH 45242, USA.

[11.] Zaka, M.Z., Saleem, M.S., Khaliq, A., and Afzal, M., 2014, 'Effect of Hand Transmitted Vibration through Tractor during Ploughing Field', International Journal of Engineering Research and Applications, volume 4, issue 12(Part 6), pp 18-23.